

Preliminary Results of Experiments to Evaluate Effects of Hook Type on Sea Turtle Bycatch in the Swordfish Longline Fishery in the Azores

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Background:

The problem of sea turtle bycatch in longline fisheries has been recognized worldwide (for review, see Balazs and Pooley 1994, Bolten et al. 1996, Williams et al. 1996). Bolten et al. (1994) presented preliminary data on bycatch of loggerhead sea turtles (*Caretta caretta*) in the swordfish longline fishery in the Azores. The waters around the Azores are an important developmental habitat for the juvenile oceanic stage of the Atlantic loggerhead population. Using mtDNA sequence analyses, Bolten et al. (1998) determined that the source rookeries for this oceanic population are primarily in the southeastern USA. Therefore, the nesting populations of loggerheads in the southeast USA are the primary populations impacted by the swordfish longline fishery in the Azores. Bjorndal et al. (2000), using a length frequency model, provided data on growth rates for this juvenile population and determined that the duration of the oceanic stage was 6.5 – 11.5 years depending upon the size at which the turtles departed the oceanic zone for the neritic zone (Figure 1).

A workshop (funded by the National Marine Fisheries Service, OPR) was held in Horta, Azores, Portugal, 2 – 4 September 1998 to review the impact of the swordfish longline fishery on sea turtles and to design an experiment to evaluate gear modification on longline bycatch rates of sea turtles (Bolten et al., 2000). This Workshop was attended by commercial longline fishermen from the Azores, fishery biologists from the Department of Oceanography and Fisheries at the University of the Azores, the Director of Fisheries from the Ministry of Agriculture and Fisheries in the Azores, and a representative of the Ministry of the Environment in the Azores. In addition, Jerry Wetherall (NMFS, Honolulu) participated and provided comparative information from other longline fisheries and ensured that the experimental design was statistically rigorous. Alan Bolten (ACCSTR, University of Florida), who has conducted sea turtle research in the Azores since 1989, convened the Workshop.

Methods:

A commercial swordfish longline vessel (25.4 meters) was contracted to conduct the experiments in the waters around the Azores. The experimental set up in 2000 consisted of the following: 93 sets were conducted between 15 July – 15 December 2000 (approximately 20 sets per month); 1500 hooks per set; the bait was squid for all sets. The experimental set up in 2001 consisted of the following: 60 sets were conducted between 1 September – 30 November 2001; 1500 hooks per set; the bait was squid for all sets. Three hook types were tested in 2000: Straight J (Mustad # 76800 D 9/0), Reversed/Offset J (Mustad #76801 D 9/0), and small Circle (Mustad # 39960 ST 16/0). Three hook types were tested in 2001: Straight J (Mustad # 76800 D 9/0), small Circle (Mustad # 39960 ST 16/0), and large Circle (Mustad # 39960 ST 18/0). In both years, the hooks were individually alternated along the set (that is, A, B, C, A, B, C, A, B...). There were 8 hooks between the buoys so that the relationship between the hook type and hook position on the gear varied.

Preliminary Results:

- In 2000, 237 turtles were captured in 93 sets (232 loggerheads, 4 leatherbacks, and 1 green turtle). Catch rate was calculated as 2.5 turtles per set (1.7 turtles per 1000 hooks); or 3.8 turtles per set for sets with turtles (2.5 turtles per 1000 hooks).
- In 2001, 44 loggerheads were caught in 60 sets.
- Not all sets caught turtles, turtles were not uniformly distributed but were clustered within the fishing area. The frequency distribution of turtles caught among sets is presented in Figure 2.
- The size range of loggerhead turtles caught was significantly different (Kolmogorov-Smirnov test, $p < 0.001$) from the overall loggerhead population in the area. The size range of loggerheads caught represents the largest turtles in the area (Figure 3).
- In 2000, there was no significant difference in the total numbers of turtles caught by each hook type (Chi-square test, $p = 0.136$).
- There was a significant difference among the hook types in the location of the hooks in the turtles. The straight J hook had a significantly greater rate of turtles caught in the throat compared to the 16/0 circle hook (Chi-square test, $p < 0.001$): 53% of the loggerheads caught on J hooks were hooked in the throat compared with 8% for circle hooks. This difference may have important implications for sea turtle mortality.
- The effect of hook position along the mainline on turtle bycatch was not significant (Chi-square test, $p = 0.518$). There was a trend for increased numbers of loggerheads to be caught on the hook closest to the buoy line, but this trend was not significant.

- There was a significant effect in the rate of turtles caught as the hour of day of line retrieval increased ($r^2 = 0.86$, $p < 0.001$; Figures 4 and 5). The rate of fish caught remained constant as hour of day of line retrieval increased ($p = 0.7$).
- Based on satellite telemetry data, there are significant differences in the post-hooking behavior of hooked turtles vs. behavior of controls with respect to dive depth and dive time and turtle movement patterns.

Conclusions:

- Experiments can be conducted successfully in the Azores with the commercial fleet, and the results can be exported to other regions and ocean basins.
- High turtle bycatch rate in the waters around the Azores allows for a rigorous experimental design and statistical analyses.
- Use of circle hooks significantly decreased the rate of throat hooking in loggerhead turtles. This result has important implications for reduced sea turtle mortality.
- Hour of day of longline retrieval had a significant effect on the rate of loggerhead turtles caught. Therefore, retrieval of the longline earlier in the day would reduce the interaction with loggerhead turtles.
- In summary, gear modification has excellent potential to reduce sea turtle interaction and bycatch.

Acknowledgments:

This project was funded by US National Marine Fisheries Service contracts: NA96FE0393 and NA16FM1378.

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Figure 1: Size-frequency distributions of oceanic-stage loggerheads captured in waters around the Azores (left-hand curves, $n = 1692$) and neritic-stage loggerheads stranded in southeastern USA (right-hand curves, $n = 1803$) (modified from Bjorndal et al. 2000, 2001). Percentages were calculated for each population. Dashed lines are cubic smoothing splines ($df = 15$); vertical reference line is at the intersection of the two smooths at 53 cm CCL.

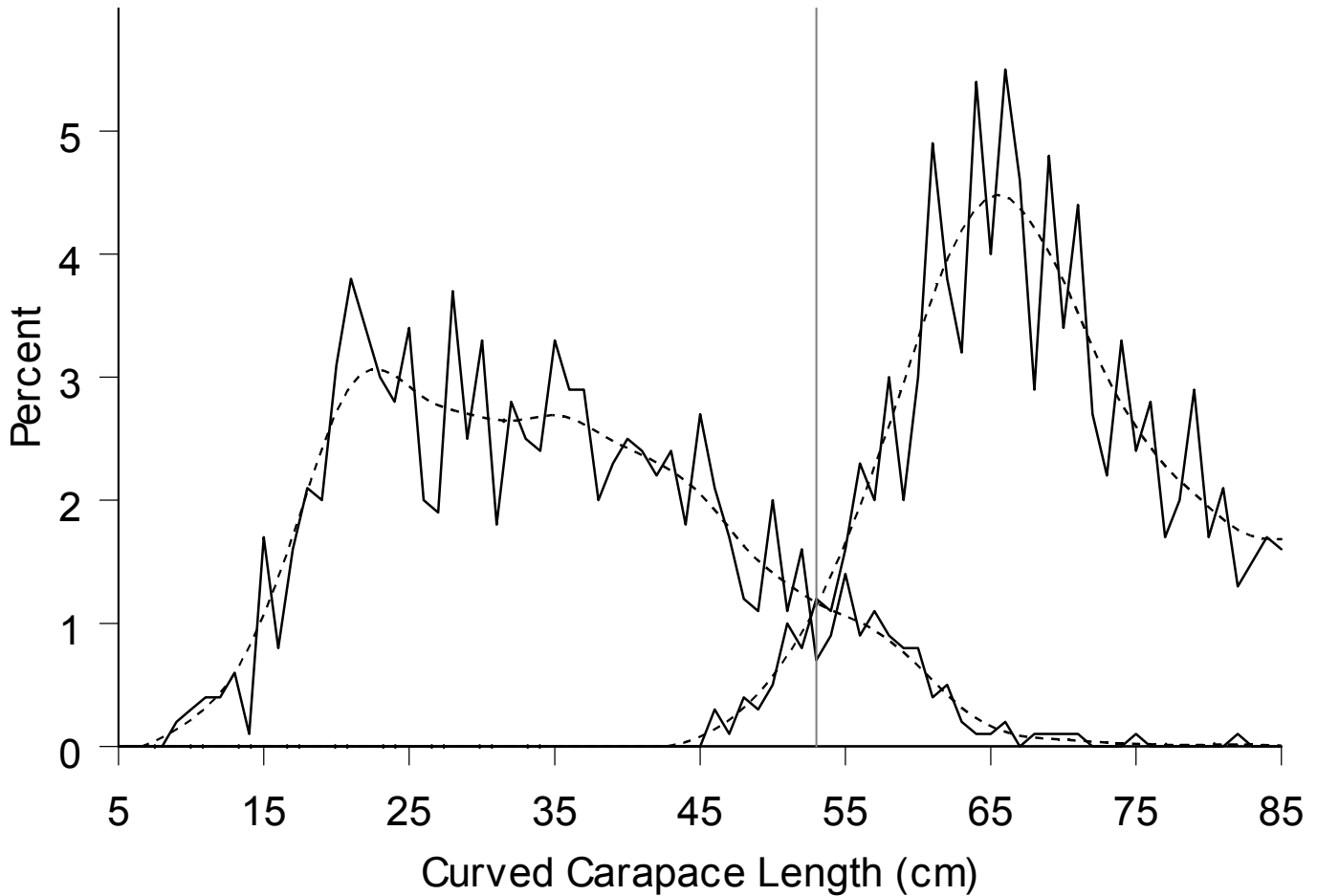


Figure 2: Frequency distribution of the number of turtles caught per set.

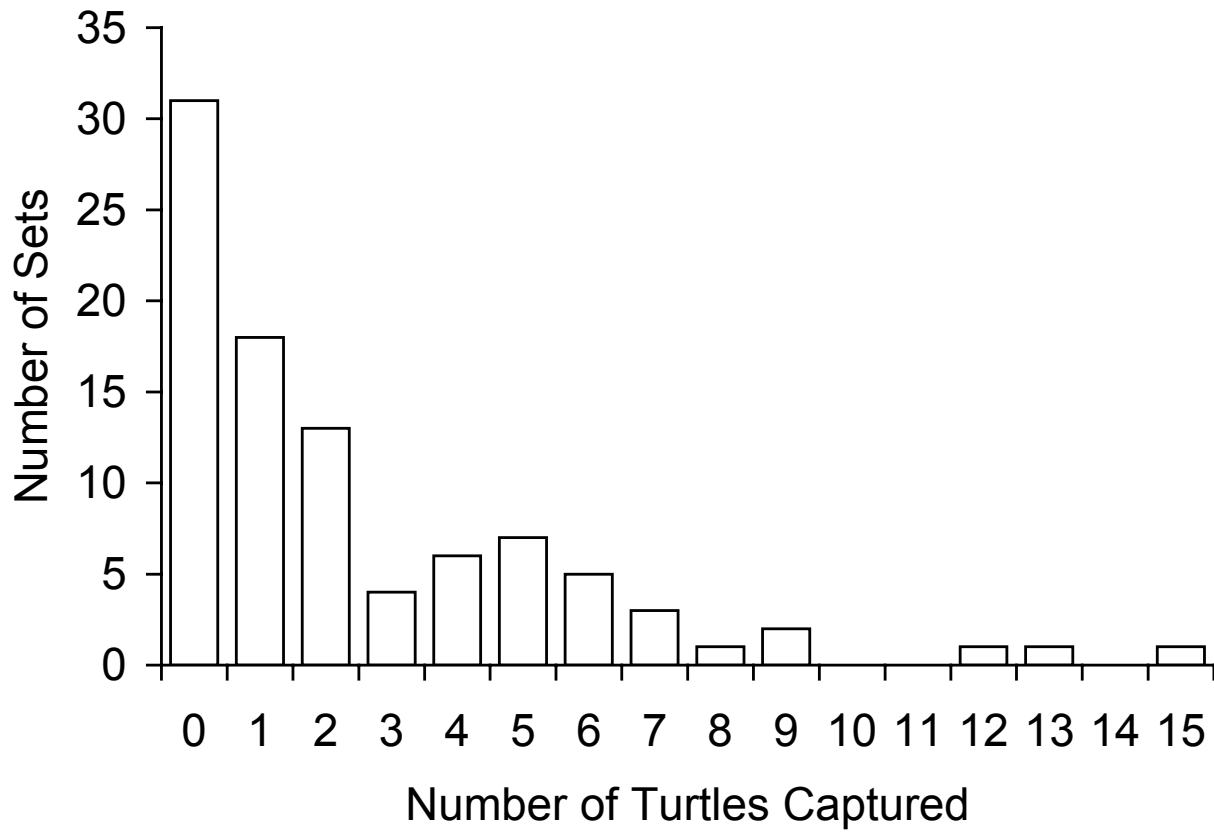


Figure 3: The size distribution of loggerhead turtles caught on the swordfish longline during the experiment (hatched bars) compared with the overall size distribution of loggerheads in Azorean waters (open bars, data from Bjorndal et al. 2000). There is a significant difference in the two distributions; turtles caught on the longline are significantly larger (Kolmogorov-Smirnov test, $ks = 0.6522$, $p < 0.001$).

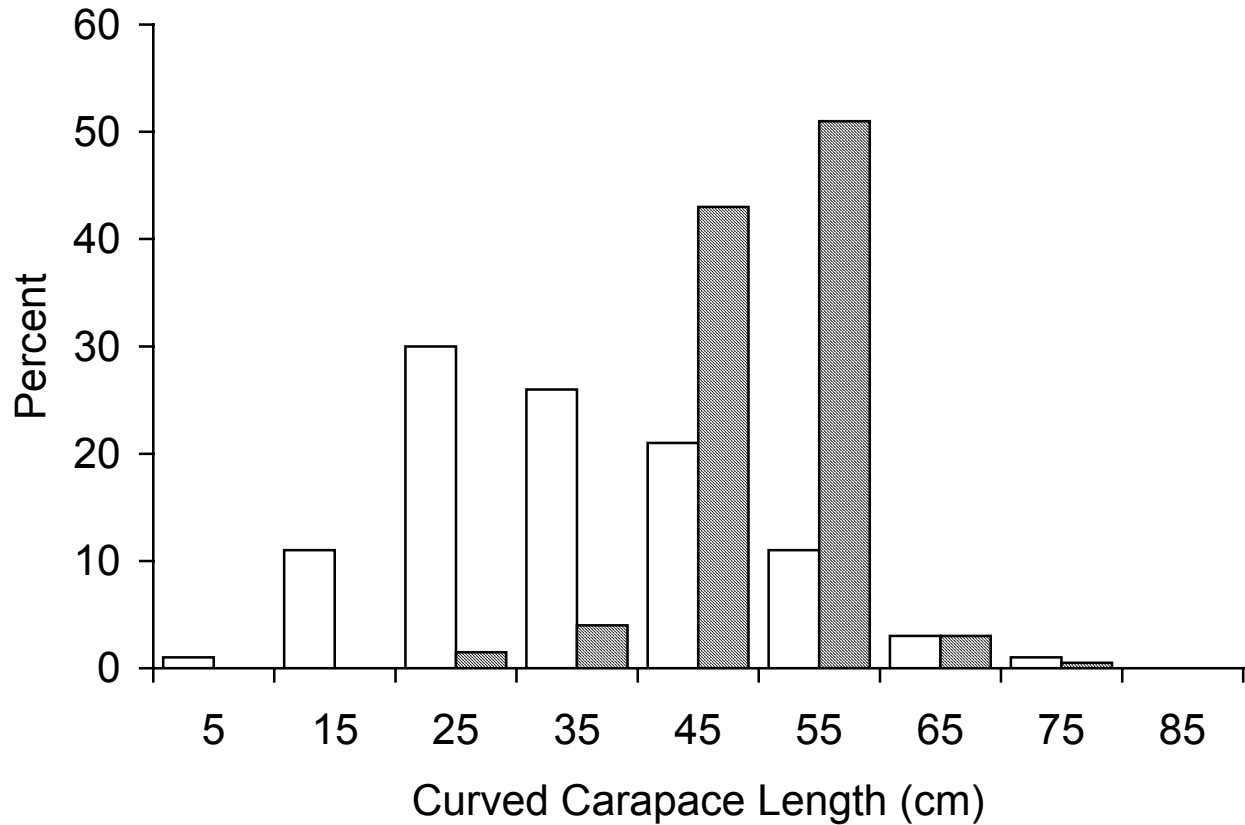


Figure 4: The relationship between both the rate of turtles caught and the rate of fish caught and the hour of day that the longline was retrieved. The rate of turtles caught increased as the hour of day increased (see Figure 5). The rate of fish caught remained constant as hour of day of line retrieval increased ($p = 0.7$).

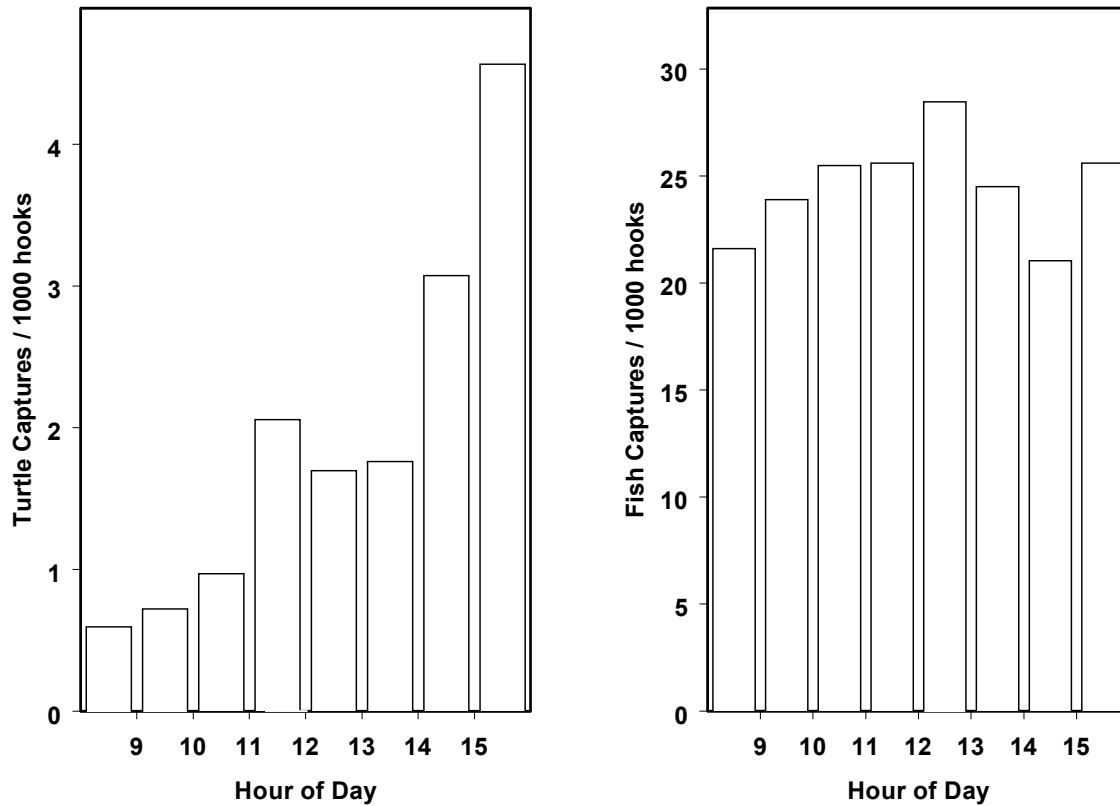


Figure 5: The relationship between the rate of turtles caught and the hour of day that the longline was retrieved. There was a significant effect in the rate of turtles caught as the hour of day of longline retrieval increased ($r^2 = 0.86$, $p < 0.001$).

